Form 6

Name:_____

Class:_____ No.: _____

Final Examination 2020/21
PHYSICS

Time Allowed: 2 hours 30 minutes

GENERAL INSTRUCTIONS

(1) There are TWO sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question book, while Section B contains conventional questions printed separately in Question-Answer Book B.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book. The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.

(4) The diagrams in this paper are NOT necessarily drawn to scale.

(5) The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A

1. Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first insert the information required in the spaces provided.
2. When told to open this book, you should check that all the questions are there. Look for the words 'END OF SECTION A' after the last question.
3. All questions carry equal marks.
4. ANSWER ALL QUESTIONS. You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.
5. You should mark only ONE answer for each question. If you mark more than one answer, you will receive NO MARKS for that question.
6. No marks will be deducted for wrong answers.

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

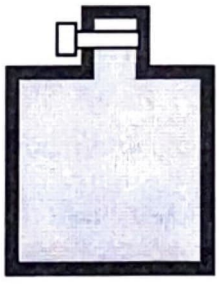
1. A microwave oven is used to heat up 0.2 kg of water at 20 °C. Energy is transferred to the water at a constant rate of 800 W. How long does it take to boil away all the water in the glass?
(The specific latent heat of vaporization of water is 2 260 000 J kg^{-1}. The specific heat capacity of water is 4 200 J kg^{-1} $°C^{-1}$.)

A. 84 s
B. 565 s
C. 649 s
D. 724 s

2. When water vapour condenses, which of the following statements is/are correct?
(1) The average intermolecular distance between water molecules decreases.
(2) The internal energy of water decreases.
(3) The average kinetic energy of water molecules decreases.

A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3) only

*3. An ideal gas is held in a constant volume container fitted with a valve through which gas can escape.



Starting at 250 K, the temperature of the gas is raised by 1000 K while its pressure in he container is allowed to double.
What fraction of the original number of gas molecules escape through the valve?

A. 0.4
B. 0.5
C. 0.6
D. 0.9

4. A car is travelling with uniform acceleration along a straight road. The road has marker posts every 100 m. When the car passes one post, it has a speed of 10 ms^{-1} and, when it passes the next one, its speed is 20 ms^{-1}. What is the car's acceleration?

A. 0.67 ms^{-2}
B. 1.5 ms^{-2}
C. 2.5 ms^{-2}
D. 6.0 ms^{-2}

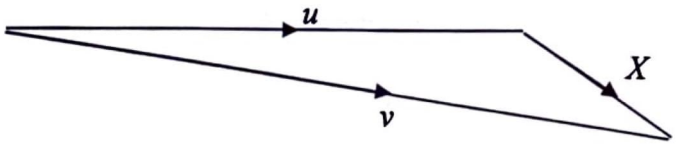
5. An experiment is done to measure the acceleration of free fall of a body from rest.
What measurements are needed?

A. the height of fall and the time of fall
B. the height of fall and the weight of the body
C. the mass of the body and the height of fall
D. the mass of the body and the time of fall

6. A ball falls vertically and bounces on the ground. The following statements are about the forces acting while the ball is in contact with the ground.
Which statement is correct?

A. The force that the ball exerts on the ground is always equal to the weight of the ball.
B. The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.
C. The net force acting on the ball is always greater than the weight of the ball.
D. The weight of the ball is always equal and opposite of the force that the ground exerts on the ball.

7. An object has an initial velocity u. It is subjected to a constant force F for t seconds, causing a constant acceleration a. The force is not in the same direction as the initial velocity.
A vector diagram is drawn to find the final velocity v.



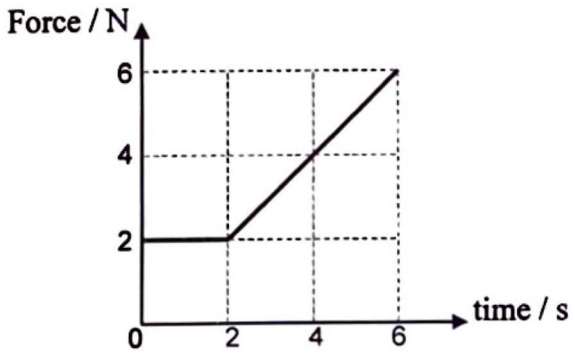
What is the meaning of the length of side X in the vector diagram?

A. F
B. Ft
C. at
D. u + at

8. Two railway trucks of masses m and 3m move towards each other in opposite directions with speeds 2v and v respectively. These trucks collide and stick together.
What is the speed of the trucks after the collision?

A. v/4
B. v/2
C. v
D. 5v/4

9. The graph shows how the force acting on a body varies with time.



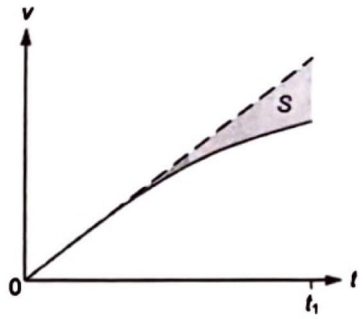
Assuming that the body is moving in a straight line, by how much does its momentum change?

A. 40 kg ms^{-1}
B. 36 kg ms^{-1}
C. 20 kg ms^{-1}
D. 16 kg ms^{-1}

10. An object in a space capsule orbiting the Earth seems to be floating.
Which statement describes the forces acting on the object?

A. There are no forces on the object.
B. The centripetal force acting on the object is zero.
C. The centripetal force acting on the object is equal and opposite to its weight.
D. The weight of the object is the only force acting on it.

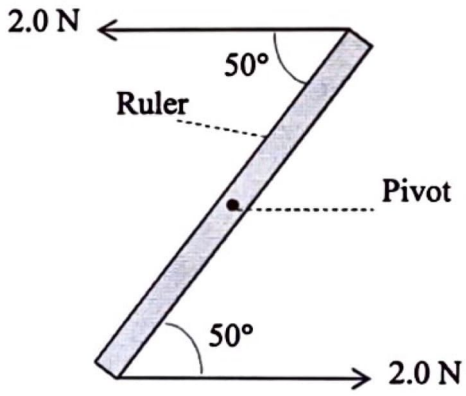
11. A ball is released from rest at a certain height above the ground. The graph (solid line) below shows how the velocity v of the ball changes with time t. Which of the following statements about the ball **must be incorrect**?



(1) The total mechanical energy of it from $t = 0$ to t_1 is conserved.
(2) At $t = t_1$, the distance travelled by it is represented by the area of the shaded region S.
(3) At $t = t_1$, the air resistance against it is greater than the gravitational force acting on it.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

12. A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown.



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A. 0.46 Nm
B. 0.64 Nm
C. 0.72 Nm
D. 0.79 Nm

13. A ball is thrown vertically upwards. Neglecting air resistance, which statement is correct?

A. The kinetic energy of the ball is greatest at the greatest height attained.
B. By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.
C. By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.
D. The potential energy of the ball increases uniformly with time during the ascent.

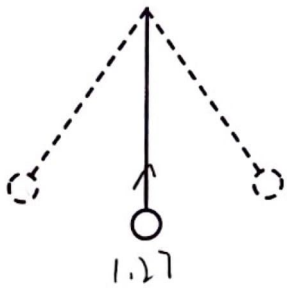
14. An electric motor is required to haul a cage of mass 400 kg up a mine shaft through a vertical height of 1200 m in 2.0 minutes. What will be the electrical power required if the overall efficiency is 80%? (Take g as 10 ms^{-2})

A. 3.2 kW
B. 5.0 kW
C. 32 kW
D. 50 kW

15. A car of mass 1.2×10^3 kg travels along a horizontal road at a speed of 10 ms^{-1}. It then accelerates at 0.20 ms^{-2}. At the time it begins to accelerate, the total resistive force acting on the car is 160 N. What is total output developed by the car as it begins the acceleration?

A. 0.80 kW
B. 1.6 kW
C. 2.4 kW
D. 4.0 kW

*16. A pendulum bob of mass 1.27 kg is supported by a string so that the radius of its path is 0.600 m. It is moving with velocity 0.575 ms^{-1} horizontally at the centre of its motion when the string is vertical. What is the tension in the string at this instant?

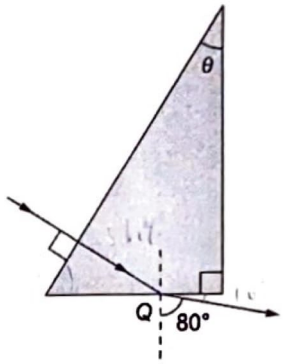


A. 11.8 N
B. 12.5 N
C. 13.2 N
D. 13.7 N

*17. A satellite of mass m is placed in an equatorial orbit so that it remains vertically above a fixed point on the Earth's surface. If ω is the Earth's angular velocity of rotation and M is the Earth's mass, what is the radius of the satellite's orbit?

A. $\left(\frac{GM}{\omega^2}\right)^{\frac{1}{3}}$
B. $\left(\frac{Gm}{\omega^2}\right)^{\frac{1}{3}}$
C. $\left(\frac{GMm}{\omega^2}\right)^{\frac{1}{3}}$
D. $\left(\frac{GMm}{\omega^3}\right)^{\frac{1}{2}}$

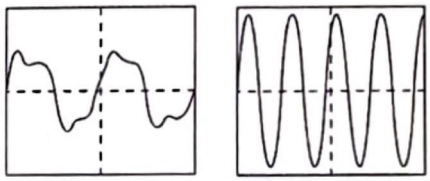
18. A monochromatic light strikes a triangular glass prism as shown below.



If the refractive index of glass is 1.55, find the angle θ of the glass prism.

A. 83.6°
B. 74.3°
C. 50.6°
D. 39.4°

19. The figures below show the waveforms of two notes P and Q, recorded by a CRO under the same settings.



note P note Q

Which of the following comparisons between P and Q are correct?

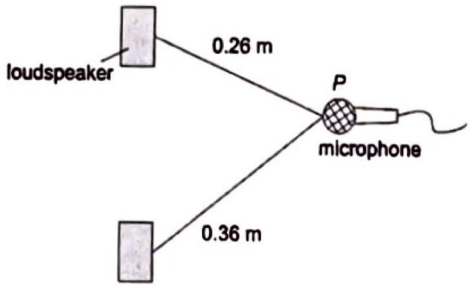
(1) Notes P and Q have different qualities.
(2) The pitch of note P is lower than that of Q.
(3) The loudness of note P is lower than that of Q.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

20. In a Young's double slit experiment, the distance between the slits and the screen is 0.5 m. The wavelength of the incident light is 7×10^{-7} m and the slit separation is 3×10^{-5} m. If a bright fringe A is approximately 4.67 cm away from the zeroth-order bright fringe, what is the order of A?

A. first
B. second
C. third
D. fourth

21. Two loudspeakers emit the same note in the same phase as shown in the figure below.

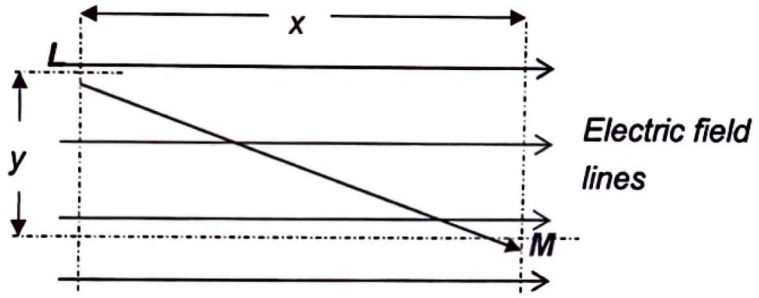


Only soft sound is recorded at point P by microphone. Which of the following could be the possible wavelength of the note?

(1) 0.20 m (2) 0.15 m (3) 0.10 m

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

22. A small positive charge, placed at a point L inside a uniform electric field, experiences a force of magnitude F. The charge is moved from point L to point M.



What is the change in the potential energy of the charge?

A. gain of Fx
B. loss of Fx
C. gain of $F\sqrt{x^2+y^2}$
D. loss of $F\sqrt{x^2+y^2}$

23. An oil drop of mass m, carrying a charge q, is in the region between two horizontal plates. When the potential difference between the upper and lower plates is V, the drop is stationary. The potential difference is then doubled. What is the initial upward acceleration of the drop?

A. g
B. 2 g
C. $\frac{2qV}{m}$ - g
D. $\frac{2qV}{m}$

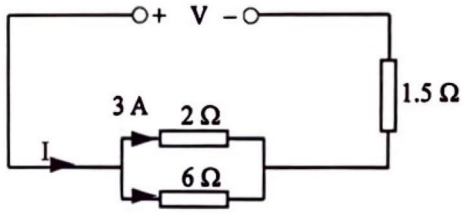
24. A thermocouple is connected across a galvanometer of resistance 30 Ω. One junction is immersed in water at 373 K and the other in ice at 273 K. The e.m.f. of the thermocouple is 90 μV for each 1 K difference in temperature between the junctions, and the thermocouple resistance is 6 Ω. What current will flow in the galvanometer?

A. 1.8 μA
B. 250 μA
C. 300 μA
D. 1.5 μA

25. The filament of a 240 V, 100 W electric lamp heats up from room temperature to its operating temperature. As it heats up, its resistance increases by a factor of 16.
What is the resistance of this lamp at room temperature?

A. 36 Ω
B. 580 Ω
C. 1.5 Ω
D. 9.2 Ω

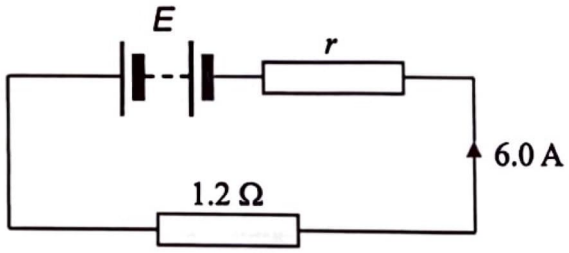
26. In the circuit shown, there is a current of 3 A in the 2 Ω resistor.



What are the values of the current I delivered by, and the voltage V across the power supply?

	I / A	*V* / V
A.	3	10.5
B.	4	9.0
C.	4	12.0
D.	12	18.0

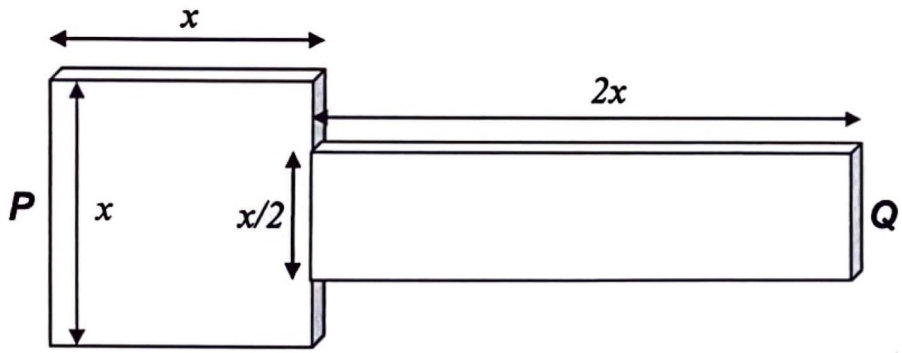
27. A battery of internal resistance r and e.m.f. E can supply a current of 6.0 A to a resistor of resistance 1.2 Ω. The circuit is shown in the diagram.



When the resistor is changed to another one having a value of 1.6 Ω, the current becomes 5.0 A. What are the values of the e.m.f. E and internal resistance r?

	E / V	r / Ω
A.	7.6	0.073
B.	12.0	2.0
C.	12.0	0.80
D.	15.0	8.0

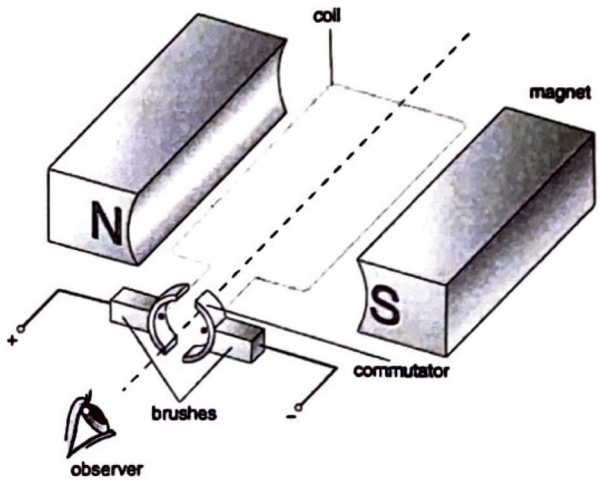
28. A thin square sheet of metal of uniform thickness and of side x has a resistance of 4.0 Ω measured between opposite edges. It is connected to another sheet of the same metal of the same thickness but of length 2x and width x/2.



What is the resistance between edges P and Q?

A. 8 Ω
B. 12 Ω
C. 16 Ω
D. 20 Ω

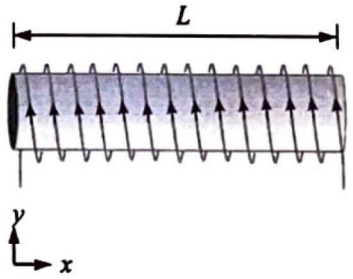
29.



The above figure shows a d.c. motor. Which of the following statements about the motor is **incorrect**?

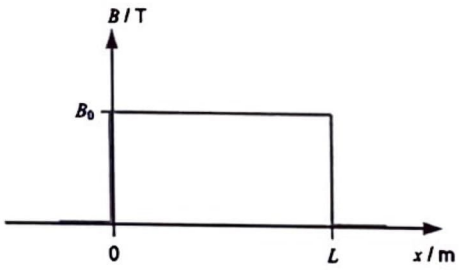
A. The coil as seen by the observer rotates in an anticlockwise direction.
B. The rotating speed of the coil can be increased by increasing the number of turns of the coil.
C. The turning effect of the coil can be increased by using a stronger magnet.
D. The coil cannot rotate continuously in one direction.

30.

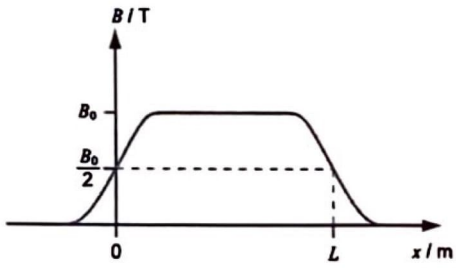


Which of the following figures best shows the variation of the magnitude B of the magnetic field along the central axis of the above solenoid of finite length L?

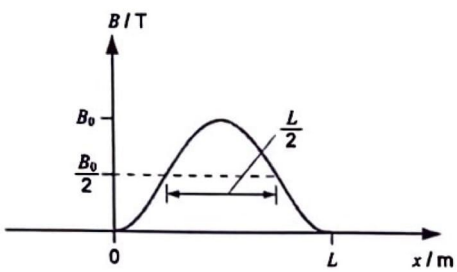
A.



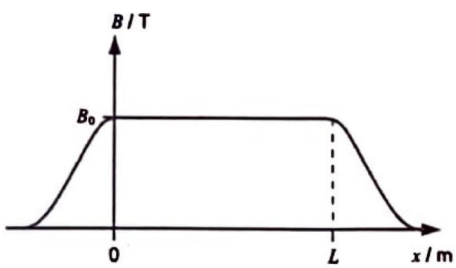
B.



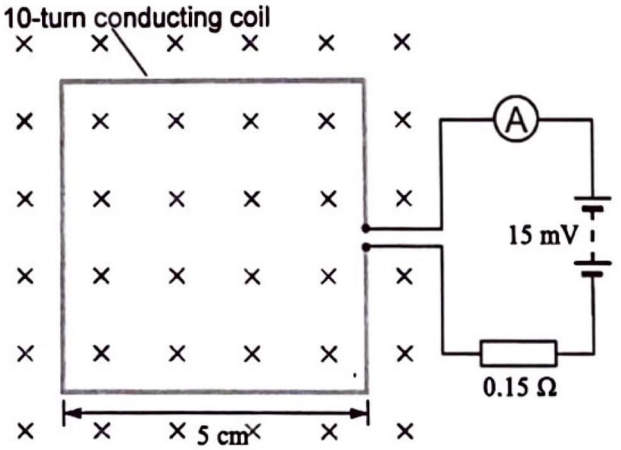
C.



D.



31. A 10-turn square conducting coil, a 0.15 Ω resistor, a battery of e.m.f. 15 mV and an ammeter are connected into a circuit shown below. A uniform magnetic field is applied perpendicularly to the coil and its magnitude is decreasing at a constant rate of 0.25 T s^{-1}. Find the reading of the ammeter.



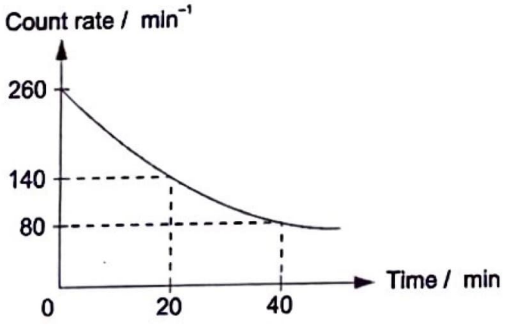
A. 58.3 mA
B. 95.8 mA
C. 100 mA
D. 142 mA

32. In the natural decay series of uranium-235, the nuclide $^{235}_{92}U^{*}$ decays to $^{207}_{82}Pb$ through a series of radioactive decays. Which of the following statements about the decay series are correct?

(1) $^{235}_{92}U^{*}$ is an unstable nuclide.
(2) γ radiation is emitted in the decay process.
(3) 7 α particles and 4 β particles are emitted in the decay process.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

*33. In a laboratory, a data logger is used to measure the count rate of a particular radioactive source. The figure on the right shows the result. Find the background radiation of the laboratory.



A. 260 min^{-1}
B. 80 min^{-1}
C. 20 min^{-1}
D. Since the half life of the radioactive source is unknown, the background radiation of the laboratory cannot be calculated.

~ End of section A ~

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$	
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$	
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)	
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$	
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$	
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$	
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$	(1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$	
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$	
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206\ 265\ \text{AU}$	
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = \kappa\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{\kappa}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e{v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2{\varepsilon_0}^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\Delta T$	energy transfer during heating and cooling	D1.	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
A2.	$E = l\Delta m$	energy transfer during change of state	D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
A3.	$pV = nRT$	equation of state for an ideal gas	D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
A4.	$pV = \frac{1}{3} Nm\overline{c^2}$	kinetic theory equation	D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy	D5.	$R = R_1 + R_2$	resistors in series
			D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force	D7.	$P = IV = I^2R$	power in a circuit
B2.	moment = $F \times d$	moment of a force	D8.	$F = BQv \sin\theta$	force on a moving charge in a magnetic field
B3.	$E_P = mgh$	gravitational potential energy	D9.	$F = BIl \sin\theta$	force on a current-carrying conductor in a magnetic field
B4.	$E_K = \frac{1}{2} mv^2$	kinetic energy	D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
B5.	$P = Fv$	mechanical power	D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration	D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
B7.	$F = \frac{Gm_1 m_2}{r^2}$	Newton's law of gravitation	D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference	E1.	$N = N_0 e^{-kt}$	law of radioactive decay
C2.	$d \sin\theta = n\lambda$	diffraction grating equation	E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens	E3.	$A = kN$	activity and the number of undecayed nuclei
			E4.	$\Delta E = \Delta mc^2$	mass-energy relationship

Form 6

Name:_____

Class:_____ No.: _____

Form 6 PHYSICS
2020 - 2021

Final Examination

SECTION B: Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first insert your information in the spaces provided on Page 1.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers of Section B in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

(5) Graph paper and supplementary answer sheets will be provided on request. Insert the information required, mark the question number box, and attach them INSIDE this Question-Answer Book.

(6) No extra time will be given for inserting your information after the 'Time is up' announcement.

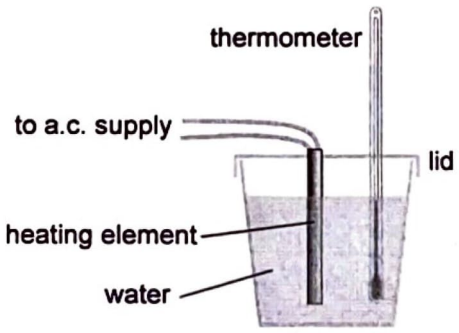
Marker' s Use Only

Question No.	Marks
1	/ 10
2	/ 11
3	/ 11
4	/ 11
5	/ 11
6	/ 5
7	/ 8
8	/ 11
9	/ 6
Total	/ 84

Section	Marks
A	
B	

Q.1

In a science project competition, a student is required to perform an experiment to find the r.m.s. and peak output voltages of an sinusoidal a.c. power supply. He connects a heating element to the supply to raise the temperature of 0.220 kg water in 5 minutes as shown.



The initial and final temperatures of the water are 25.0 °C and 55.5 °C respectively. The operating resistance of the heating element is 12 Ω. The specific heat capacity of water is 4200 J kg^{-1} $°C^{-1}$. Assume all the energy supplied to the heating element is transferred to the water.

(a) Find the average power supplied to the heating element. (3 marks)

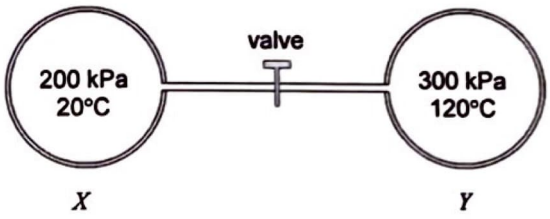
(b) Find the r.m.s. and peak output voltages of the a.c. power supply. (4 marks)

(c) Suggest two improvements to the experiment. (2 marks)

(d) Suggest a device that can be used to find out the peak output voltage directly. (1 mark)

Q.2

X and Y are two identical insulated containers connected by tube with a valve which is initially closed. X contains an ideal gas at 200 kPa at 20°C. Y contains the same gas at 300 kPa at 120°C.



The valve is now opened. The system finally becomes steady.

(a) What is the final temperature of the gas? (3 marks)

(b) What is the final gas pressure of the gas? (2 marks)

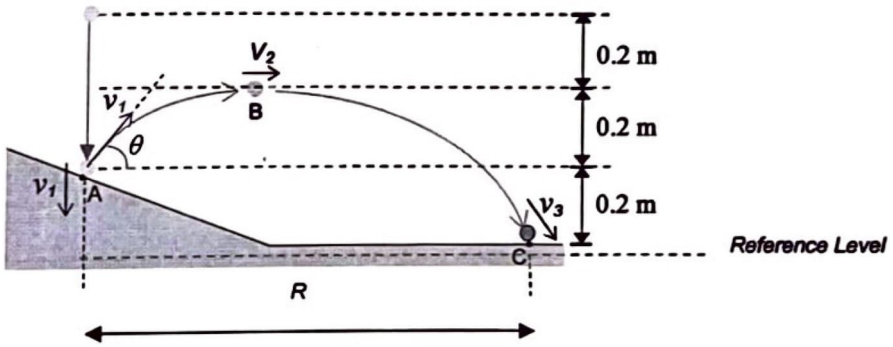
Q.2

(c) Using kinetic theory, explain how molecular movement causes the gas pressure inside a container. (3 marks)

(d) The density of neon gas at a temperature of 273 K and a pressure of 1.02×10^5 Pa is 0.9 kg m^{-3}. Neon may be considered as an ideal gas. Calculate the root-mean-square speed of neon atoms at 273 K. (3 marks)

Q.3

An elastic ball of mass 0.3 kg is released from rest at a height of 0.6 m above a reference level. It falls onto an inclined plane at point A and rebounds at a speed v_1. Then it reaches a maximum height of 40 cm above the reference level while its horizontal speed is v_2. Finally, the ball reaches the reference level at a speed v_3.



Assume that no energy is lost when the ball bounces off the inclined plane.

(a) Find v_1 at point A. (2 marks)

(b) Find v_2 at point B. (2 marks)

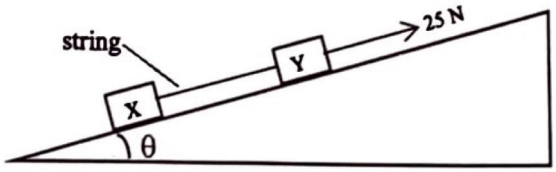
(c) Find the angle θ. (2 marks)

Q.3

(d) Find the horizontal distance travelled (R) by the ball. (3 marks)

(e) Hence or otherwise, find v_3 at point C. (2 marks)

Q.4



Two blocks X and Y of masses 4 kg and 3 kg respectively are connected by an inextensible light string. A constant force of 25 N is applied on Y to pull the blocks up an inclined plane at a constant speed of 3.5 m s^{-1} as shown above. The plane makes an angle θ with the horizontal. The frictional force between each block and the inclined plane is 2 N.

(a) Find the angle θ. (3 marks)

(b) Suddenly, the string breaks at t = 4 s.

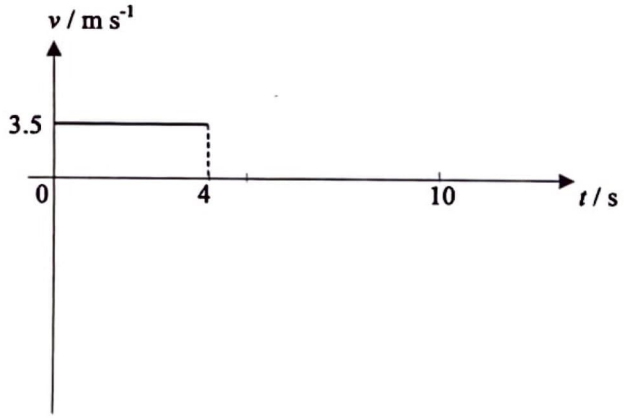
(i) Find the acceleration of block Y after t = 4 s. (2 marks)

(ii) How long does it take for block X to reach its highest position? (2 marks)

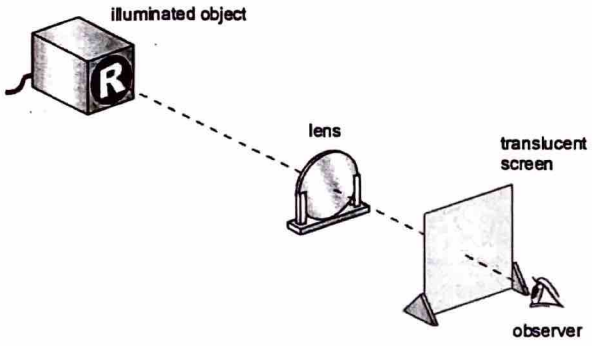
Q.4

(b) (iii) Find the speed of block X at t = 10 s. (2 marks)

(c) Sketch the v-t graph for block X from t = 0 s to t = 10 s. (2 marks)



Q.5



A student uses the above set-up to study the image formation of a lens. An illuminated object is placed 30 cm in front of the lens. A translucent screen is placed on the other side of the lens. When the screen is moved to a position 50 cm away from the lens, a sharp image is observed.

(a) (i) What kind of lens is used by the student? Explain your answer briefly. (2 marks)

_____

_____

_____

_____

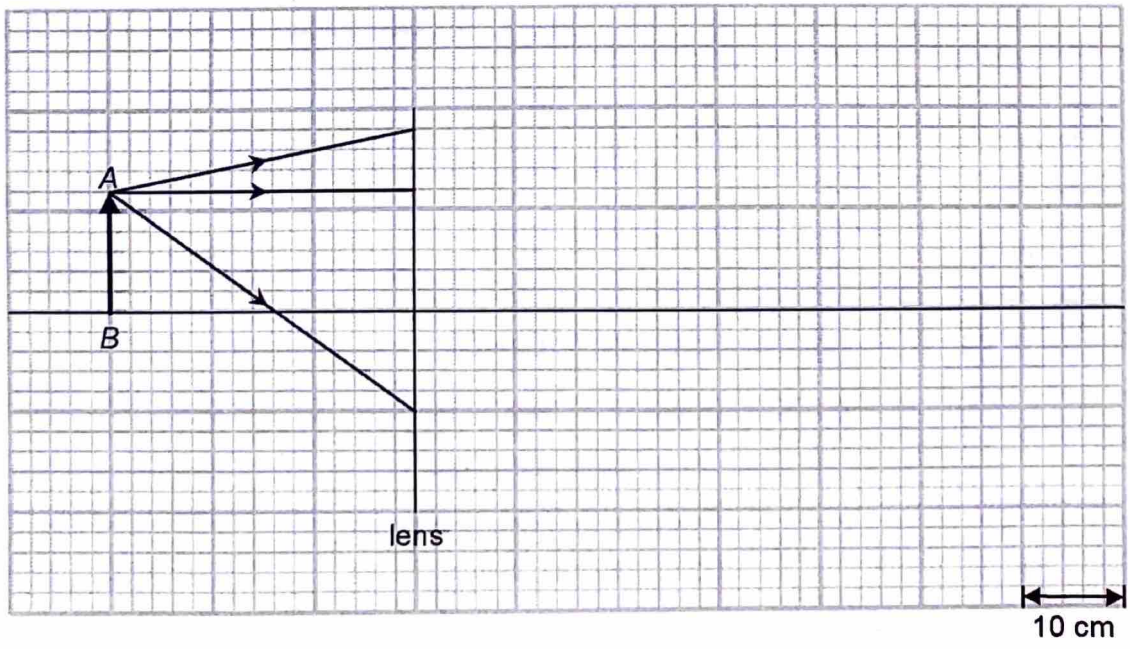
(ii) Sketch the image observed by the student. (1 mark)

(iii) State the nature of the image. (2 marks)

_____

_____

(b) In the figure below, AB represents the illuminated object.



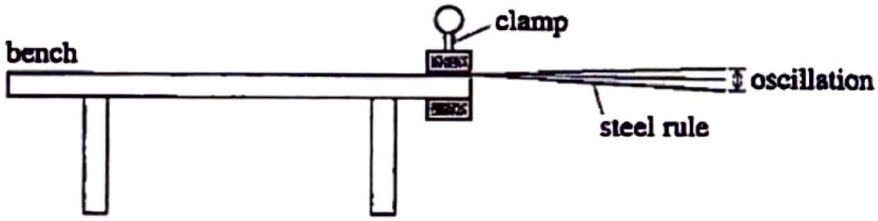
(i) **In the above diagram**, draw the refracted light rays and the image A′B′ of the object. (2 marks)

(b) (ii) Calculate the linear magnification of the image. (2 marks)

(iii) Find the focal length of the lens. (1 mark)

(c) How would the image formed on the screen be affected if the lower half of the lens is covered by a piece of opaque paper? (1 mark)

Q.6



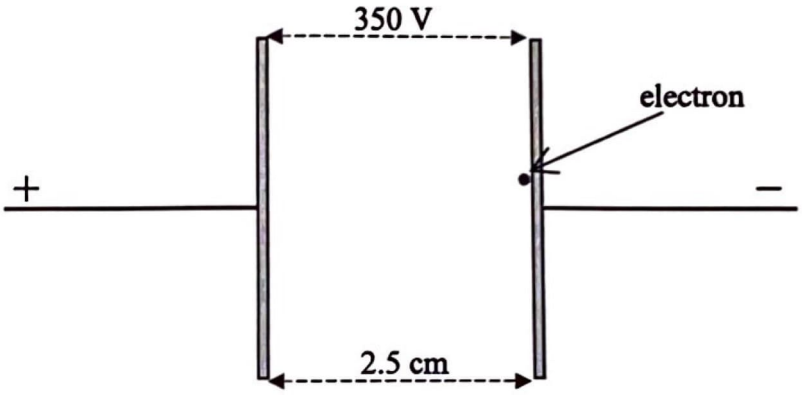
A 60 cm steel rule is held by a clamp on the side of a bench as shown above. The length of the steel rule hanging over the bench is 54 cm. The free end of the rule is pressed down and then released. The rule then oscillates vertically and it takes 18 s to complete 50 oscillations.

(a) Name the wave set up in the oscillating rule. (1 mark)

(b) Find the wavelength of the wave. (2 marks)

(c) Find the speed of the wave in the oscillating rule. (2 marks)

Q.7 Two vertical parallel metal plates are situated 2.5 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown below.



An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) (i) Calculate the magnitude of the electric field between the plates. (2 marks)

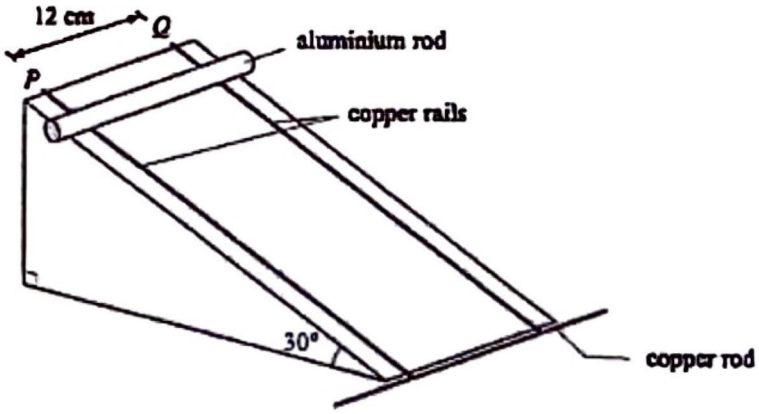
(ii) Find the force acting on the electron due to the electric field. (2 marks)

(b) The electron accelerates horizontally across the space between the plates. Neglect the gravitational effects on the electron. Determine

(i) the horizontal acceleration of the electron, (2 marks)

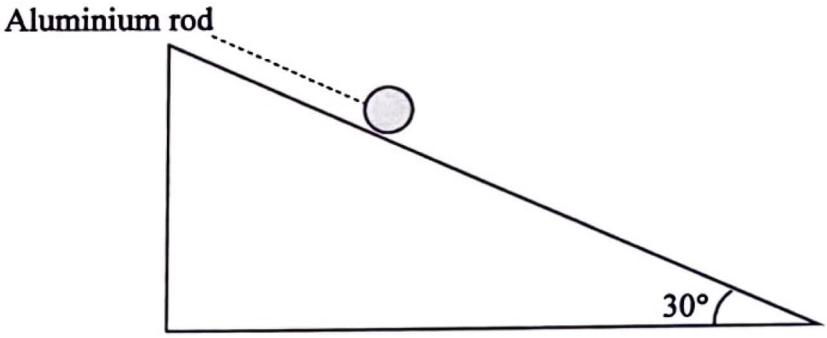
(ii) the time to travel the horizontal distance of 2.5 cm between the plates. (2 marks)

Q.8



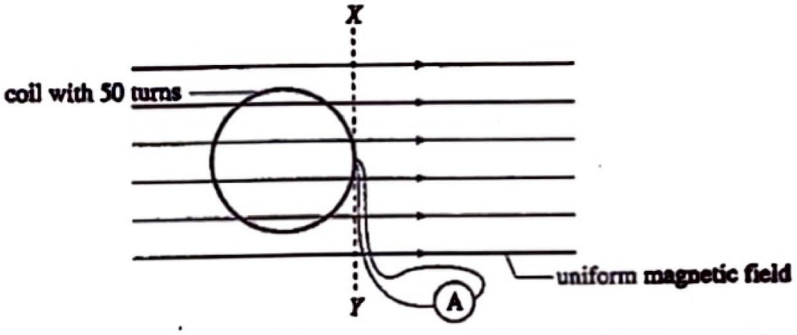
Two parallel smooth copper rails are fixed on a slope inclined at 30° with the horizontal. The lower ends of the rails are connected by a fixed copper rod. The whole system is placed inside a region of uniform upward magnetic field of flux density 2 T. An aluminium rod of mass 3 g is placed on the rails and then released from rest as shown above. The resistance of the aluminium rod is 0.03 Ω and that of the copper rails is negligible. At a certain instant, the speed of the rod is 0.01 m s^{-1}.

(a) The diagram below shows the side view of the slope and the aluminium rod. Draw the free body diagram to show all forces acting on the moving rod. (3 marks)



(b) Find the induced current flowing through the moving rod at that instant. (3 marks)

• Q.8



Mary uses an alloy to make a circular coil with 50 turns and places it inside a uniform magnetic field as shown above. The magnetic field is 6 T and the diameter of the coil is 8 cm. Initially, the plane of the coil is parallel to the magnetic field. She rotates the coil by 90° about the vertical line XY in 2 seconds.

(c) Find the average induced *e.m.f.* in the coil. (2 marks)

(d) The resistivity (ρ) of the alloy used is 2×10^{-6} Ω m and the cross-section of the alloy wire has an area of 0.5 mm^2. Find the average induced current in the coil. (3 marks)

Q.9

Caesium-137 is a radioactive isotope of Caesium which is formed in the fission of uranium-235. It has a half-life of 30.2 years. In nuclear power plants, the radioactive products are kept in the fuel rods. But in an accident of a nuclear power plant, radiation due to Cs-137 can be detected around the site.

(a) There are 82 neutrons in a Cs-137 nucleus and it decays by emitting a radiation which carries a negative charge. Write an equation for the decay. Use symbol X as the name of the daughter nucleus. (2 marks)

(b) In the contaminated area, the count rate read by a GM tube is 700 min^{-1} which is approximately 10 times the background count rate.

(i) Find the decay constant for Cs-137. (2 marks)

(ii) Estimate the time in years for the count rate to drop to the normal level. (2 marks)

~ End of paper ~

Section C : Energy and Use of Energy

Pre-Mock Multiple-choice questions

34 If an incandescent lamp of power rating 40 W has an end-use energy efficiency of only 15%, which of the following statements is correct?

A. 40 J of electromagnetic radiation is emitted from the lamp every second.
B. 34 J of heat is released from the lamp every second.
C. 34 J of infra-red radiation is emitted from the lamp every second.
D. 6 J of visible light is emitted from the lamp every second.

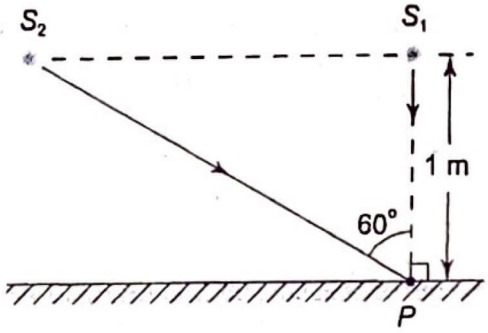
A B C D
○ ○ ○ ○

35 The spectrum of the electromagnetic radiation emitted from a filament lamp is

A. a continuous spectrum, because the energy levels of the atoms of the filament are closely spaced.
B. a continuous spectrum, because the energy levels of the atoms of the filament are widely spaced.
C. a line spectrum, because the energy levels of the atoms of the filament are closely spaced.
D. a line spectrum, because the energy levels of the atoms of the filament are widely spaced.

A B C D
○ ○ ○ ○

36 A point P on a surface is illuminated by two identical lamps S_1 and S_2. The luminance of each of them is 2000 lm as shown in the diagram. The two lamps are at the same height of 1 m above the surface. S_1 is vertically above P, while S_2 makes an angle of 60° with the normal at P. What is the illuminance at P?



A. 179 lx
B. 193.6 lx
C. 198.9 lx
D. 238.7 lx

A B C D
○ ○ ○ ○

37 A cubic refrigerator has side lengths of 0.6 m. All its surfaces are 1 cm thick and are made of an insulating material of conductivity 0.02 W m^{-1} K^{-1}. Suppose heat enters the interior of the refrigerator via all its surfaces (6 surfaces) at a rate of 40 W. Estimate the temperature difference between the inside and the outside of the surfaces of the refrigerator.

A. 5.56 °C
B. 9.26 °C
C. 18.5 °C
D. 55.6 °C

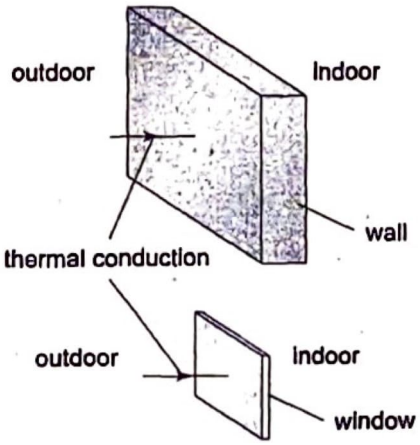
A B C D
○ ○ ○ ○

38 An insulated room of size 3 m × 4 m × 5 m at an initial temperature of 32 °C is cooled by an air-conditioner of cooling capacity 1.8 kW. If the air-conditioner is turned on for 5 minutes, what is the final temperature of the room? (Given: density of air= 1.2 kg m^{-3}, specific heat capacity of air = 1000 J kg^{-1} K^{-1})

A. 22.3 °C
B. 24.5 °C
C. 26.2 °C
D. 28.8 °C

A	B	C	D
○	○	○	○

39



A wall and a window belong to the same house. The wall has its area and thickness both 10 times those of the window. The U-value of the wall is 1/5 that of the window. If a temperature difference exists between indoor and outdoor, what is the ratio of the rate of conduction through the wall to that through the window?

A. 1 : 5
B 2 : 5
C. 2 : 1
D. 5 : 2

A	B	C	D
○	○	○	○

40 Which of the following statements about the moderation of a pressurized water reactor is incorrect?

A. The moderation is required for maintaining the chain reaction.
B. The moderation is done by water.
C. In the moderation, the average speed of the neutrons is reduced.
D. If the moderation process accidentally stops, the fuel rods of the reactor would melt down.

A	B	C	D
○	○	○	○

41 The average wind speed in a wind farm is 11 m s^{-1} and the air density is 1.2 kg m^{-3}. 150 identical wind turbines are to be erected in the wind farm so as to output an average electrical power of 100 MW. The wind turbines can capture 40% of the wind power and have an efficiency of 70% in generating electricity. What should be the diameter of the rotors of the wind turbines so that they could meet the electrical power output requirement?

A. 48.3 m
B. 54.1 m
C. 61.6 m
D. 66.8 m

A	B	C	D
○	○	○	○

Section D: Medical Physics

Pre-Mock Multiple-choice questions

42 Helen is observing two point objects which reflect green light of wavelength 520 nm. The two objects are 3 mm apart and are 15 m from Helen's eyes. The diameter of the pupil of Helen's eye is 4 mm. Which of the following statements about whether the two point objects can be resolved or not is correct?

A. The two point objects can just be resolved.
B. The two point objects cannot be resolved but begin to be resolvable if they are moved closer to Helen's eyes for a distance of 5 m.
C. The two point objects can be resolved but begin to be unresolvable if they are moved away from Helen's eyes for a distance of 4 m.
D. The two points objects can be resolved but begin to be unresolvable if they are moved away from Helen's eyes for a distance of 19m.

A B C D
○ ○ ○ ○

43 The minimum power of a normal eye (with range of accommodation from 25 cm to infinity) is 38 D. What is the maximum power of the eye?

A. 42 D
B. 43 D
C. 44 D
D. 45 D

A B C D
○ ○ ○ ○

44 A listener is at a certain distance from a source of sound of a certain power. He/she can hear sound from the source at a certain sound intensity level. The listener then moves closer to the source and the power of the source is increased so that finally the distance is halved while the power is doubled. What is the increase in the sound intensity level?

A. 3 dB
B. 8 dB
C. 9 dB
D. 80 dB

A B C D
○ ○ ○ ○

45 Ultrasound can penetrate into our bodies, but some body tissues are more difficult to penetrate than the others. Arrange the following body tissues (bone, fat, lung, muscle) in ascending order of difficulty (from the least difficult to the most difficult) for ultrasound to penetrate.

A. Lung, fat, muscle, bone
B. Fat, muscle, bone, lung
C. Fat, lung, muscle, bone
D. Muscle, bone, fat, lung

A B C D
○ ○ ○ ○

46 Which of the following statements about high frequency ultrasound (10 - 12 MHz) scanning (as compared with low frequency ultrasound scanning (2 - 5 MHz)) is/are correct?

(1) It provides better resolution.
(2) It has higher penetrating power.
(3) It is less safe.

A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A B C D
○ ○ ○ ○

47 Which of the following statements about incoherent optical fibre bundle are correct?

(1) Incoherent optical fibre bundle can transmit light but not image.
(2) The relative positions of the optical fibres in an incoherent optical fibre bundle are not preserved from one end to the other.
(3) Incoherent optical fibre bundle is cheaper than coherent optical fibre bundle.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

A	B	C	D
○	○	○	○

48 Which of the following is **not** an advantage of X-ray imaging for medical diagnosis?

A. It is a quick method for medical imaging.
B. It can give good quality image of high resolution.
C. It can provide an effective first stage medical diagnosis.
D. It is a cheap method for screening diseases in large population.

A	B	C	D
○	○	○	○

49 A patient received a radionuclide imaging of the liver. A suitable radionuclide emitting gamma rays was taken by the patient and a series of images were taken by a gamma camera at different times. Which of the following statements about the images is/are correct?

(1) The images show the attenuation of the gamma rays by the liver.
(2) The images show the distribution of the radionuclide in the liver.
(3) The images give information about the function of the liver.

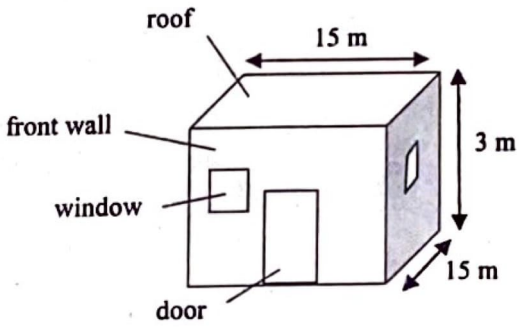
A. (1) only
B. (2) only
C. (1) and (3) only
D. (2) and (3) only

A	B	C	D
○	○	○	○

Pre-Mock Structured question

Q1

The figure below shows a hut of dimensions 15 m × 15 m × 3 m. On each wall there is a double-glazed window with low-e glass of area 1.2 m^2. A wooden door of size 2 m × 1 m is installed on the front wall. The U-values the window and the door are 1.8 W m^{-2} K^{-1} and 3.7 W m^{-2} K^{-1} respectively, the U-value of the remaining part of wall and roof is 2.3 W m^{-2} K^{-1}.



(a) Find the average U-values of the following building components.

(i) A side wall with a window (2 marks)

(ii) The front wall with a door and a window. (2 marks)

(b) The rate of heat transfer by radiation per unit area of the window is 80 W m^{-2}. In summer time, the outdoor temperature is about 33 °C. The hut is air-conditioned so that the indoor temperature is maintained at about 24 °C.

(i) Find the rate of heat transfer by conduction through the hut envelope. (2 marks)

(ii) Find the rate of heat transfer by radiation through the windows. (1 mark)

(iii) What is the minimum cooling capacity of the air-conditioner required to maintain the indoor temperature at about 24 °C? (1 mark)

(iv) Find the Overall Thermal Transfer Value (OTTV) of the hut. Suggest a way to reduce the OTTV of the hut. (2 marks)

Q2

The figures show an X -ray radiographic image and computed tomography (CT) scan of chest.

A

B

(a) (i) Which figure (A or B) is the X -ray radiographic image of chest? (1 mark)

(ii) Explain how the image is formed in terms of the effects on the passage of X-rays through different media including soft tissue and bone. (2 marks)

(iii) The intensity of a beam of X-ray drops to 14 % of its initial value after passing through a lung. If the thickness of the lung is 11.6 cm, what is the linear attenuation coefficient of the lung for the X-ray beam, expressed in m^{-1} ? (2 marks)

(b) (i) State an advantage of a CT scan over X -ray radiographic imaging. (1 mark)

(ii) Although CT images have the above advantage than using X-ray, give TWO reasons (other than CT scanners are more expensive) why conventional X-ray radiographic imaging has not been completely replaced by CT imaging. (2 marks)

(c) The effective dose of a chest X-ray radiographic imaging and a chest CT scan are shown below.

	effective dose (mSv)	equivalent background radiation dose (days)
chest X-ray radiographic imaging	0.02	1.85
chest CT scan	6.6	610.5

(i) Briefly explain why the effective dose of a CT scan is much higher. (1 mark)

(ii) A head CT scan has an effective of 1.5 mSv. Based on the information from the table, estimate its equivalent background radiation dose. (1 mark)

END OF PAPER